AWWA Source Water Protection Committee

Assessing the Economic Basis for Forest Cover on Water Treatment Costs

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Technical and Educational Council
U.S. Endowment for Forestry and Communities

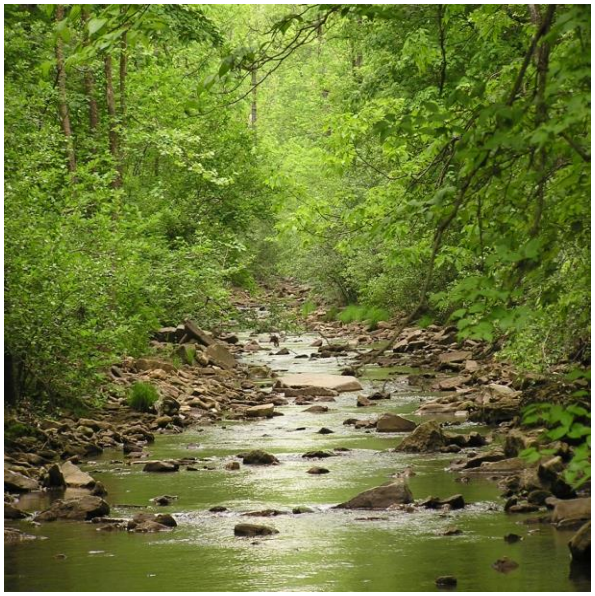
Beaver Water District

Objective

- Explore relationship of forest cover to treatment cost;
  - Forest : Water Quality
  - Water Quality: Treatment Cost
  - Forest : Treatment Cost
- Is payment for ecosystem services cost effective?

Beaver Water District

Background; Forests = Better Water Quality



Forest watersheds

- >1/2 of surface water sources
- Water for > 212 million
- Ecosystem services
  - Regulate flow
  - Filter pollutants
- Source of fewer pollutants than other land use
- Better water quality wrt water treatment

Background; Better Water Quality = Lower Cost

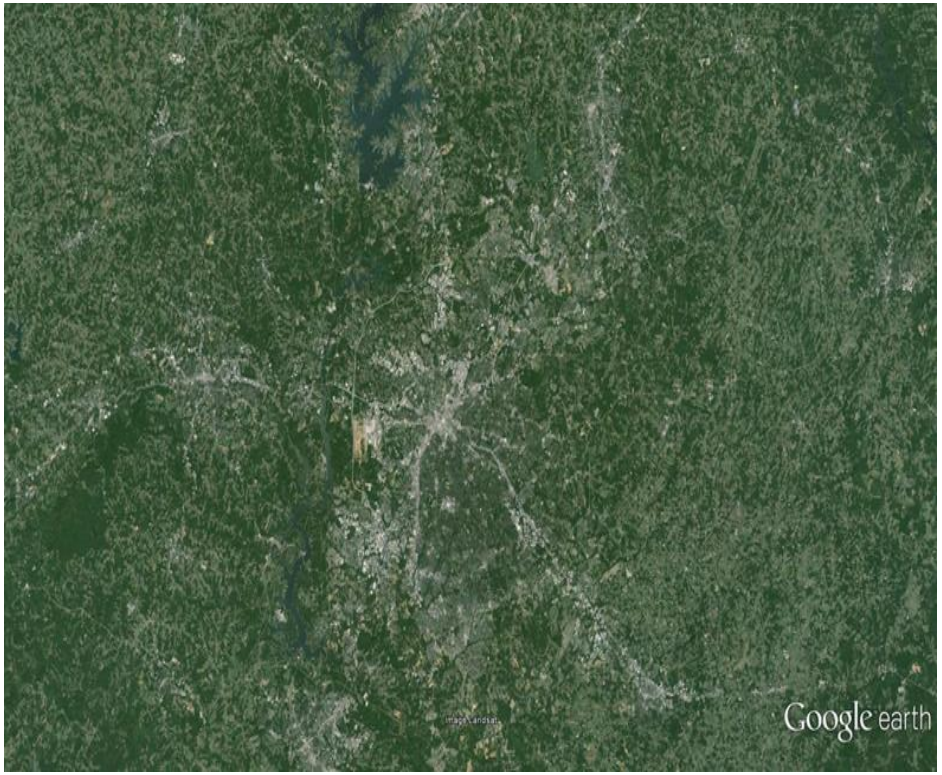
- Less chemical use:
  - Coagulants
  - Filter aids
- Less treatment residuals
- Simpler treatment process
- 1% reduced turbidity ~ 1/10 to 1/3% decrease chemical cost
  - (Moore et al., Forster et al., Dearmont et al., Holmes)
- Lots of confounding factors!

Background: A Changing World

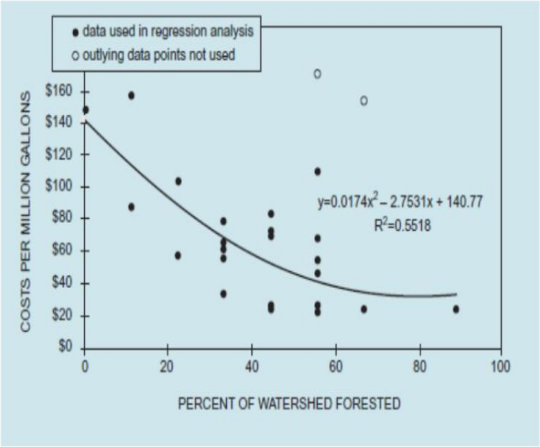
- Land use change
- Forest fragmentation
- Loss of ecosystem service

- Forest conservation as SWP tool
  - Safer, potentially more economical source
  - Can provide value to forest land owner

- Beneficiary pays



Previous Work



- Trust for Public Lands
  - 1997: Protecting the Source
  - 2004: Update
    - Roughly 50% of treatment cost variation explained by forest cover
    - 10 % increase in forest; 20% decrease in chemical costs
  - 2008: White Paper
    - Land cover associated with source water quality
    - Decreasing forest leads to increasing total organic carbon (TOC)
    - Treatment cost directly related to TOC
  - Confounding factors; weak statistical relationships

Current Effort

- Survey of WTPs
  - Raw Water, Source and Quality
  - Cost of Treatment Chemicals
- Analysis of Watershed Condition
- Relate Watershed Condition to Cost
- Case Studies

Forested Ecoregions

NW Forested Mts.

Eastern Temperate Forests

Survey

- AWWA Database; Surface Water Systems Only
- 37 Responses
- Water Quality
  - Raw Water Turbidity, Raw Water TOC
- Source
  - River or Reservoir
- Treatment
  - Disinfection only; direct filtration; conventional; advanced
- Chemical Cost
- Production
- Public Water System Identification (PWSID)

Summary Statistics

	All treatments (N=37)					Only conventional treatment (N=26)			
Variables	Mean	St. dev.	Min	Max		Mean	St. dev.	Min	Max
Min turbidity (NTU)	1.52	1.66	0.07	10		1.40	0.83	0.07	3.2
Max turbidity (NTU)	92.03	167.8	0.68	825		96.56	165.98	1.42	825
Median turbidity (NTU)	8.07	16.34	0.30	100		6.66	5.41	0.52	23
Min TOC(MGL)	1.66	1.08	0.33	6		1.75	1.15	0.33	6
Max TOC (MGL)	4.66	4.51	1	25		5.23	5.08	1.25	25
Median TOC (MGL)	2.55	1.68	0.65	7.36		2.78	1.74	0.65	7.36

Chem. Costs by Type of Treatment $/MG

	Obs.	Mean	St. Dev.	Min.	Max.
Disinfection only/No Filtration	2	$20.8	22.4	$5.0	$36.7
Conventional Treatment	26	$106.2	101.7	$9.6	$493.4
Direct Treatment	7	$133.7	63.3	$23.5	$229.9
Advanced Treatment	2	$78.6	49.2	$43.8	$113.4

Land Use / Land Cover

- Intake location: EPA Safe Drinking Water Info. Sys.
- Matched to 10 digit HUC watershed
- 2011 USGS National Land Cover Database (NLCD)
  - Area, % forest, water, range, developed, ag., barren
- Stressors; Brown and Froemke (2012)
  - Population, Roads, Animal Units

Watershed Statistics

Variables	Mean	St. dev.	Min	Max
Forest area (%)	60%	13%	5%	86%
Developed area (%)	14%	13%	1%	48%
Agriculture area (%)	3%	4%	0%	19%
Water area (%)	2%	2%	0%	11%
Barren area (%)	0%	0.9%	0%	5%
Rangeland area (%)	21%	12%	6%	61%
Watershed drainage area (km2)	494	203	197	981
Watershed population (2000 census)	81,334	95,980	5,319	348,824
Roads density (km/km2)	2,295	1,141	937	5,996
Animal Units (weighted average)	4,802	4,587	533	20,113

Analysis

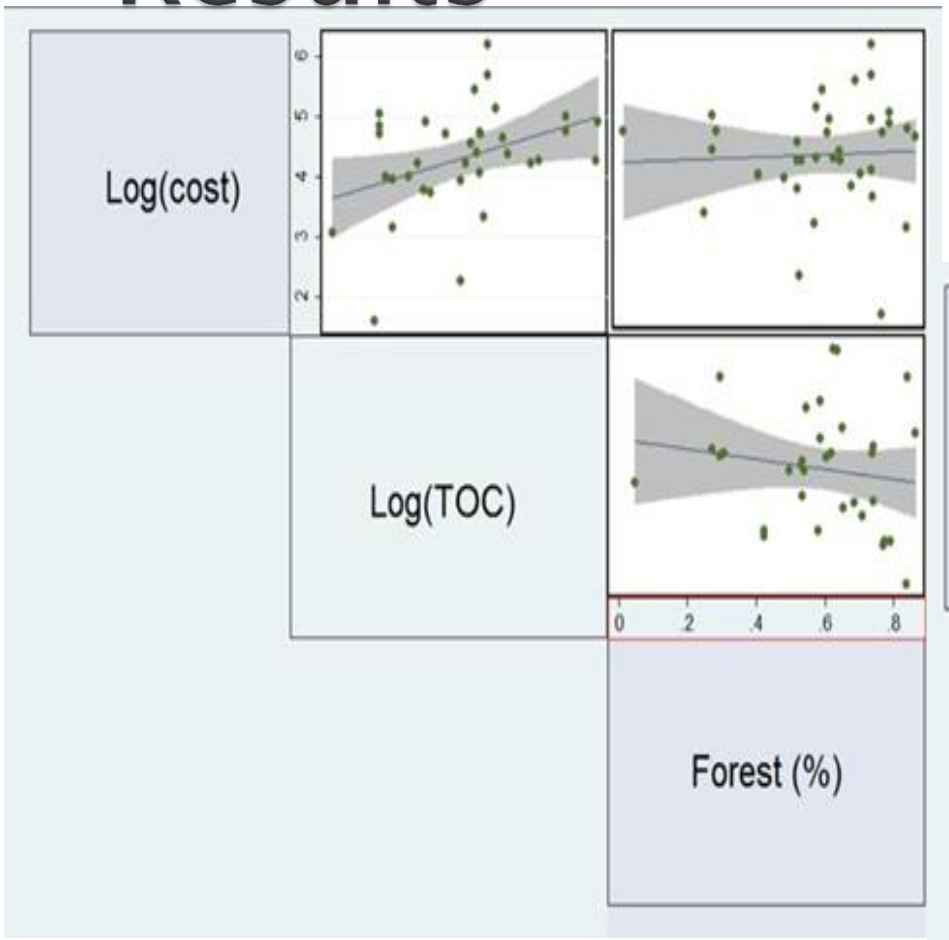
Water Quality function

- $\log(Q_i) = \beta_0 + \beta\ \mathrm{LANDUSE}_i + \gamma\ \log(\mathrm{STRESSORS}_i) + \delta_i\ \mathrm{RIVER}_i + \varepsilon_i$

Economic Benefit function

- $\log(cost_i) = \beta_0 \log(Q_i) + \beta_{pop} \log(size_i) + \beta_{dr} \log(drainage_i) + \beta_c conventional_i + \beta_d direct_i + \beta_a advanced_i + \beta_b unfiltered_i + v_i$

Results


Log(cost)
Log(TOC)
Forest (%)
2
3
4
5
6
0
.2
.4
.6
.8

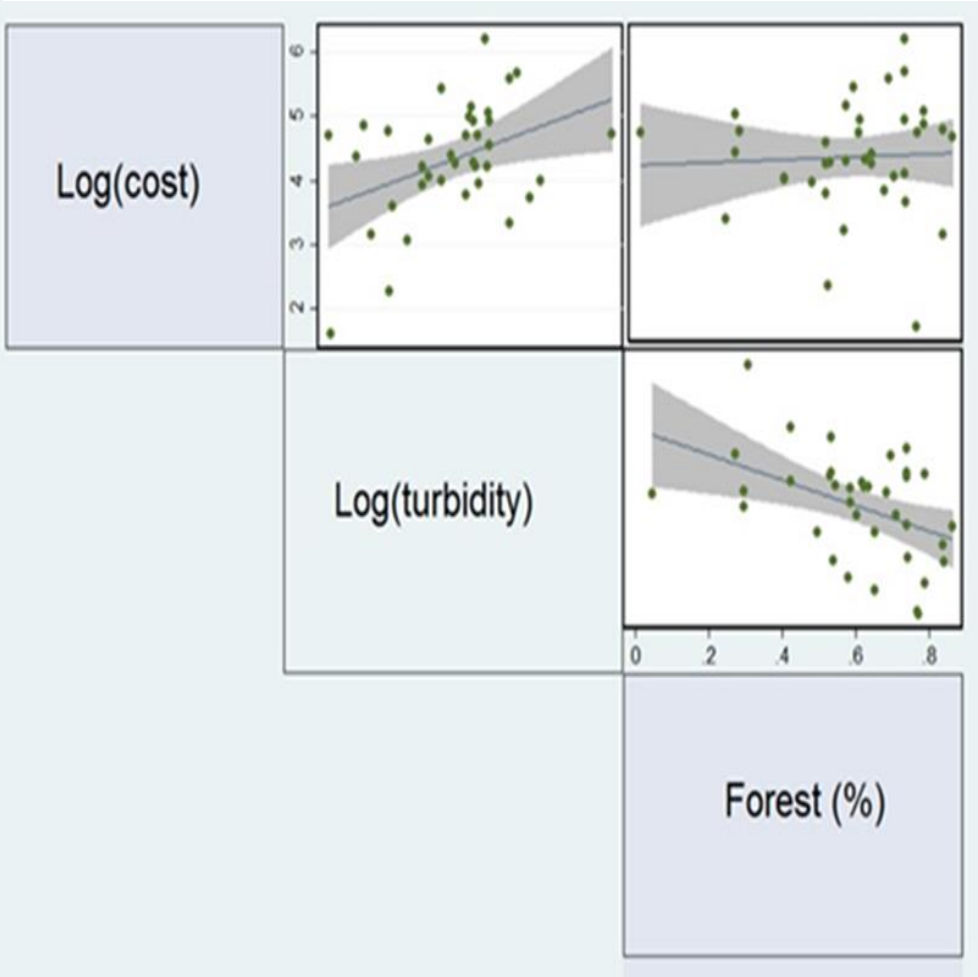

Log(cost)
Log(turbidity)
Forest (%)
2
3
4
5
6
0
.2
.4
.6
.8

Table 5 -Ecological production functions

Dependent variable:	Log(median turbidity)			Log(median TOC)	
Developed area (%)	0.038***	0.039***	0.033**	-0.003	-0.012
	(0.012)	(0.013)	(0.014)	(0.008)	(0.01)
Agriculture area (%)	-0.093**	-0.082*	-0.11**	-0.010	-0.001
	(0.041)	(0.043)	(0.045)	(0.028)	(0.035)
Rangeland (%)	0.061**	0.049**	0.052**	0.016	0.018
	(0.015)	(0.020)	(0.022)	(0.010)	(0.017)
Obs.	37	36	26	35	25
R-squared	0.56	0.46	0.41	0.18	0.24
Regression characteristic:	All observations	1 outlier eliminated (100 NTU)	Only conventional treatment	All observations	Only conventional treatment

Notes: *** p-value<0.01; ** p-value<0.05; * p-value<0.1.; Std. errors are in parenthesis.

		All types of treatment	All types of treatment	conventional treatment
Dependent variable:		Log(cost)	Log(cost)	Log(cost)
Log(turbidity)		0.19*	0.19	0.22
		(0.11)	(0.13)	(0.15)
Log(TOC)		0.46**	0.46**	0.51**
		(.19)	(0.19)	(0.22)
Log(million gal / day)		-0.19**	-0.19**	-0.2**
		(.07)	(0.08)	(.08)
Obs.		35	34	25
R-squared		0.59	0.59	0.43
Regression characteristic:		All observations	1 outlier eliminated (100 NTU)	Only conventional treatment

Notes: *** p-value<0.01; ** p-value<0.05; * p-value<0.1.; Std. errors are in parenthesis.

Benefits?
Hypothetical Average Plant in Average Watershed

% change in turbidity from a 10% change in forest cover	46%
% change in treatment costs from a 46% in turbidity	8.7%
Average treatment cost in sample ($/MG)	$105
Increase due to turbidity per million gallons treated ($/MG)	$9.61
Annual increase with an average production of 19.3 MGD	$65,000
Present value (3% discount rate, 30 years)	$1,300,000
For 122,070 acre watershed (average in study)	$106.50/acre

Results not applicable to any individual water plant!

Conclusion

- Across forested ecosystems,
  - Potential of payment for ecosystem service but:
    - Data are highly variable
    - Caution in applying to individual case
    - Need for case studies
- Other considerations!
- Other beneficiaries – Need partnerships